OPPORTUNITY TO CREATE THE SYSTEM FOR SPACE PROTECTION OF THE EARTH AGAINST ASTEROIDS AND COMETS ON THE BASE OF MODERN TECHNOLOGY

V.M.Kovtunenko, V.A.Simonenko, G.N.Rogovsky, A.N.Tchesnokov, O.V.Papkov, Iu.A.Bojor, A.V.Zaitsev, V.A.Kotin, I.D.Maglinov, I.V.Feshin
Lavochkin Association, Moscow, Russia

The main purpose of our report is to show, that already right now it is possible to begin practical steps on creation of main components of the System for Earth Protection(SEP) from hazardous space objects (HSO) - asteroids and comets. Thus we shall consider basically space components of the SEP, leaning mainly on experience of the Lavochkin Association and some other Russian and foreign firms.

For creation the SEP there is the set of the suppositions [1 ,2]. Among major of them are as follows:

- *Biological* - aspiration of whole live, and consequently the mankind, to preserve a stable equilibrium (homeostasis);
- *Ecological* - possibility of evolving of a global ecological catastrophe as result of a "trigger effect" induced by the collision even with a relatively small celestial body;
- *Political* - the end of "cold war ";
- *Technological* - creation of rocket and space means, nuclear weapons, means of telecommunication, control etc.

The development and creation of such System should satisfy to a number of requirements and restrictions. Among the major of them are:

- maximum use of actually available means;
- integration of special SEP equipment with instruments for other purposes;
- presence of a space segment of a service of HSO detection ;
- presence at least of two echelons of HSO interception service: for near (operative) and distant interceptions;
- providing of ecological safety of interception service application;
- international status of the system and etc..

It is obvious, that a pioneering stage of creation SEP should be creation of a HSO Ground and Space based Detection Service (GSDS). The necessity of creation of a space segment of the GSDS does not cause doubts. The main purpose of the segment will be providing of the celestial sphere fast review and preliminary determination of asteroids and comets trajectories. The more accurate measurements the will be carried out by ground instruments and spacecraft of a "Space Hubble" type.

Tentative estimations of the space detection means capacities, carried out by different researchers [3,4], show, that such telescopes will have rather moderate mass and energy consumption.

It will allow to install the detection means not only on special space vehicles (SV), but also as a piggy-back payloads for SV , intended for other purposes.

For this purposes may be proposed space platforms developed by Lavochkin Association: "OKO", "Spectr" and other.

SV "OKO" is regularly launching (2-3 times per year) to high elliptical and geostationary orbits; a series of the "Spectrum" SV are scheduled for launching in the nearest years.

Technical characteristics of the above mentioned SV and means of insertion to orbit permit to generate various variants of the orbital configuration of a SEP space segment (Fig. 1).

SV with telescopes can be injected to high elliptical, geostationary and heliocenrtic orbits. It may provide optimum conditions for HSO observations.

For instance, observations carried out in the L1 libration point (Earth-Sun system) may permit to find out objects, approaching to the Earth from the Sun side [5].

Instruments for HSO observation (as a part of the space segment) in this case may be easily integrated with developing now in Russia system for global heliophysics monitoring "GEKATA"[6]. It will allow to execute a complex monitoring of a space environment for SEP, branches of a national economy and science purposes. At the same time it also will stimulate development of ground means of HSO observation.

Thus use of actually existing technological potential will provide fast creation of a SEP space segment, with relatively low cost and at small technical risk.

In the long term, it will be possible to install miniature patrol complexes for HSO detection and the data processing on interplanetary SV. It will allow to register asteroids and comets in various areas of Solar system.

After creation of the GSDS all asteroids with the size more than one kilometer through some time will be detected and registered in a Catalog. It will allow make a forecast of possible collisions on many years ahead and to arrange on prevention of collisions with the help of a Distant Interception Service of SEP.

It will be impossible to register all HSO with the size less than one kilometer. Therefore they must be intercepted on near approach to the Earth by operative interception service.

It is obvious, that developing of the of distant interception service must be based on an infrastructure, created for of interplanetary space vehicles. The Lavochkin Association has considerable experience of developing, production and operation of such robotics spacecraft.

For these purposes a wide spectrum of launchers and some existed SV may be used. Modern space launchers ("Energia") are capable to inject to the interplanetary trajectories spacecraft with mass up to 25-30 metric tons.

As example of possible SV-interceptor may be considered the vehicle of a "Phobos" type (or "Mars-96"). This spacecraft where developed in the Lavochkin Association. Mass of such SV, launched by the "PROTON" LV, reaches 5-6 tons. It is capable to work at the distances, corresponding the asteroid belt. This SV can to deliver to asteroid nuclear unit with power of several megatons. It may be a single charge or several individual nuclear charges. In the last case charges will be delivered by the individual means of delivery. If necessary, several SV-interceptors may be launched.

Several problems must be resolved during development of the of interception service . In particular, one of such problems is very high accuracy required for pointing of SV-interceptor to the HSO.

For solution of the above mentioned problem may be used a method, tested during approaching of Soviet SV "VEGA" and West Europe SV "Jotto" to the Haley comet nuclei. This scheme use at first fly by of the HSO by small SV-pathfinder and then approaching of the main SV. SV-pathfinder will adjust parameters of HSO orbit and study the physical characteristics of HSO. That information will be used for selection of the scheme of the interceptor affect on the HSO.

The possible scheme of a distant interception service structure is shown on the Fig. 2.

So, even already existing space means may be substantially used for distant interception of HSO.

However, creation of a special echelon of distant interception and the maintenance of this structure in constant readiness will be extremely expensive.

Therefore it is offered, having developed the international concept of an interception service, to keep the project in permanent readiness for realization ("postponed realization "). At the same time basic components of the service may be worked off during realization of missions for Solar System exploration. It will allow to support a necessary level of readiness of the service, and to deploy the system in shortest time in case of the threat of collision with a large celestial body.

Hence, the future space missions to Solar system objects must be formed with taking in account the interests of SEP. In particular, during realization of developed in our enterprise mission "Mars-Aster" (delivery of probes to asteroid) some experiments for interception service may be fulfilled.

As against an echelon of distant interception, the echelon of close (operative) HSO interception should be maintained in a condition of permanent readiness.

For realization of practical steps on creation of an operative interception service we offer to develop the international demonstration project "Space patrol " (Fig. 3).

The purposes of this project are:

• development and testing of main components of an operative detection service and interception the asteroids, approaching to the Earth;

• study of asteroid physical characteristics from flyby and impact trajectories;

• adjustment of methods and means of action upon the HSO.

We want to stress that practically all components of the "Space Patrol " project actually exist or have a prototypes, the completion of which will not require large efforts. It will allow to realize the project by use of wide international cooperation in the shortest terms and at rather small expenses.

The realization of the "Space Patrol" project becomes possible in connection with recent new data concerning rather high frequency of flyby (about an once in a week) asteroids with diameter 50-100 m in vicinities of the Earth (fly-by distances less than 1 million km).

Such asteroids can be detected several days before closest approach to Earth. It permits, at already achieved terms of SV and LV preparation to launch, to execute the mission for asteroid inspection and testing of methods and means of action upon the HSO.

Thus, it is possible to use the near-Earth space as range for study of small celestial bodies and improvement of SEP components.

For increase of asteroids detection probability, in the nearest years alongside with development and the perfection of ground detection instruments, space telescopes must be developed within the framework of the "Space Patrol" project.

In a complex with available and prospective Russian and foreign ground instruments, including American system " Spaceguard Survey ", will be work out detection means and technology of interaction between observation centers of different countries.

In parallel with deployment of components of ground and space based detection service, small SV (SSV) with mass of 200-300 kg (as US "Clementine" spacecraft launched in 1994) should be created, for inspection of asteroids from flyby trajectories. This SSV may be used as SV-pathfinder in the structure of future SEP.

Probably, it is most attractive to use as a launch vehicles the modified decommissioned ICBM (in particular in frames of "Start-1" and "Start-2" Treaty). For these purposes can be used ICBM "SS-18" (LV "Conversion") and "SS-19" (LV "Rokot").

After installation of SSV on LV they are put on "battle" watch with use of a modified military launch complex. Thus the control of start of the given space-rocket complex should be carried out from International Center of Coordination and Management.

Fig. 4 illustrates possible variant LV "Conversion" with upper stage and SV for injection to Earth orbits or to interplanetary trajectories. In the first case mass of SV may be about 2200 kg, in second one - about 500 kg.

Two variants of SSV mission to asteroid may be considered:

- to newly discovered suitable asteroid, the trajectory of which passes on distances from the Earth achievable for SSV;
- to asteroid, the returning of which can be predicted beforehand.

In the first case the launch of SSV should be carried out at some days or hours before closest approach to the Earth. In second - with considerably large time margin.

When suitable approaching to Earth asteroid will appeared, the launch will be carried out for injection of SSV to approaching to asteroid trajectory.

During pass of a space vehicle on a flyby trajectory remote sensing will be carried out for study of the asteroid characteristics. At the same time methods of SSV control and precise navigation will be fulfilled. In this mission it is possible to deliver surface probes to asteroid (like penetrators).

After asteroid flyby the SSV can continue space researches, for example, in area of solar-Earth ties, within the framework of the developed project "GEKATA".

At the subsequent stages of work, after creation of the SV-interceptor, work out of methods and means of action on HSO will be fulfilled. Thus, for pointing of the SV-interceptor the information from earlier started SV-pathfinders will be used.

Moreover more powerful LV may be used (for instance, LV "ZENIT"). It will allow considerably to expand opportunities of study asteroids, flying close to the Earth, including, probably, asteroid sample return. This may become logic continuation of the project NEAR.

Thus, realization the first demonstration stage of SEP creation will allow essentially to expand our knowledge of properties of small celestial bodies of Solar system. But at the same time this will help to preserve and to develop the best achievement of Russia, USA and whole world community in the field of a science, engineering, manufacture, defense and etc. in interests of maintenance of safety of the whole mankind.

For realization of the "Space Patrol" project wide cooperation among main suitable organizations and enterprises should be generated.

All work should be carried out with wide cooperation of space agencies, academies of sciences and their institutes, defensive etc. organizations of all technologically advanced countries.

The limited frameworks of the report do not permit consider a set of other technical, ecological, political etc. aspects and problems of SEP creation. However, more detailed analysis, lead by the authors of the report and by other scientists and experts [7-1 2], permits to make a conclusion about necessity and opportunity of SEP development already in the near future.

Thus the expenses on space and launching components of System will be rather moderate, because in constant operation there will be only few space telescopes, and on " battle watch " will be a several LV with SV of an operative interception service. It will require much less expenditures, than is now spent by some countries on creation and maintenance of some kinds arms.

LIST OF ABBREVIATIONS

HSO - Hazardous Space Objects

SEP - System for Earth Protection

GSDS - Ground and Space Based Dedection Service

LV - Launch Vehicle

SV - Space Vehicle

SSV - Small Space Vehicle

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Схема обнаружения опасных космических объектов

Sceme of the DSO detection

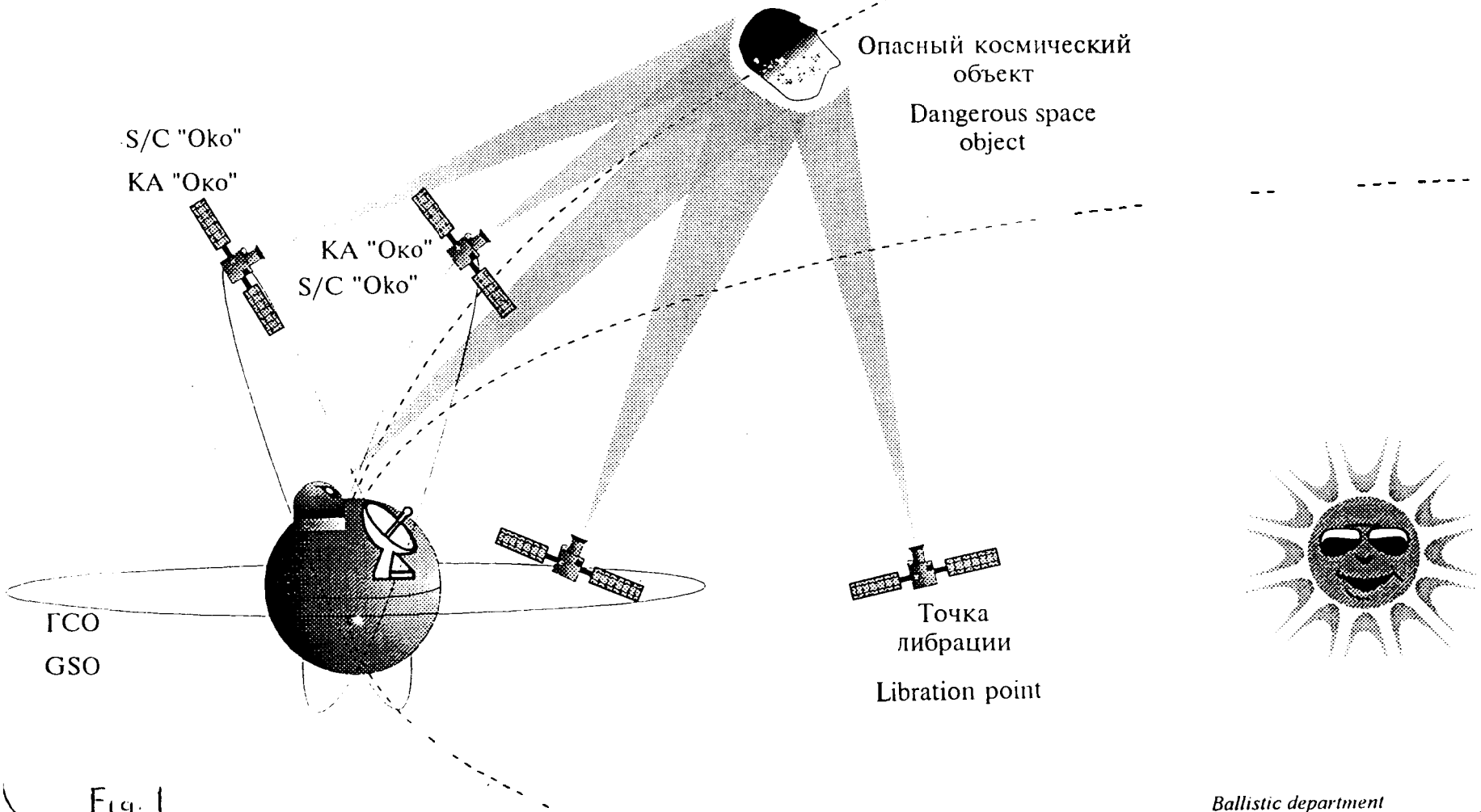

Fig. 1

Схема перехвата опасных космических объектов

Scheme of the Dangerous Space Object interception

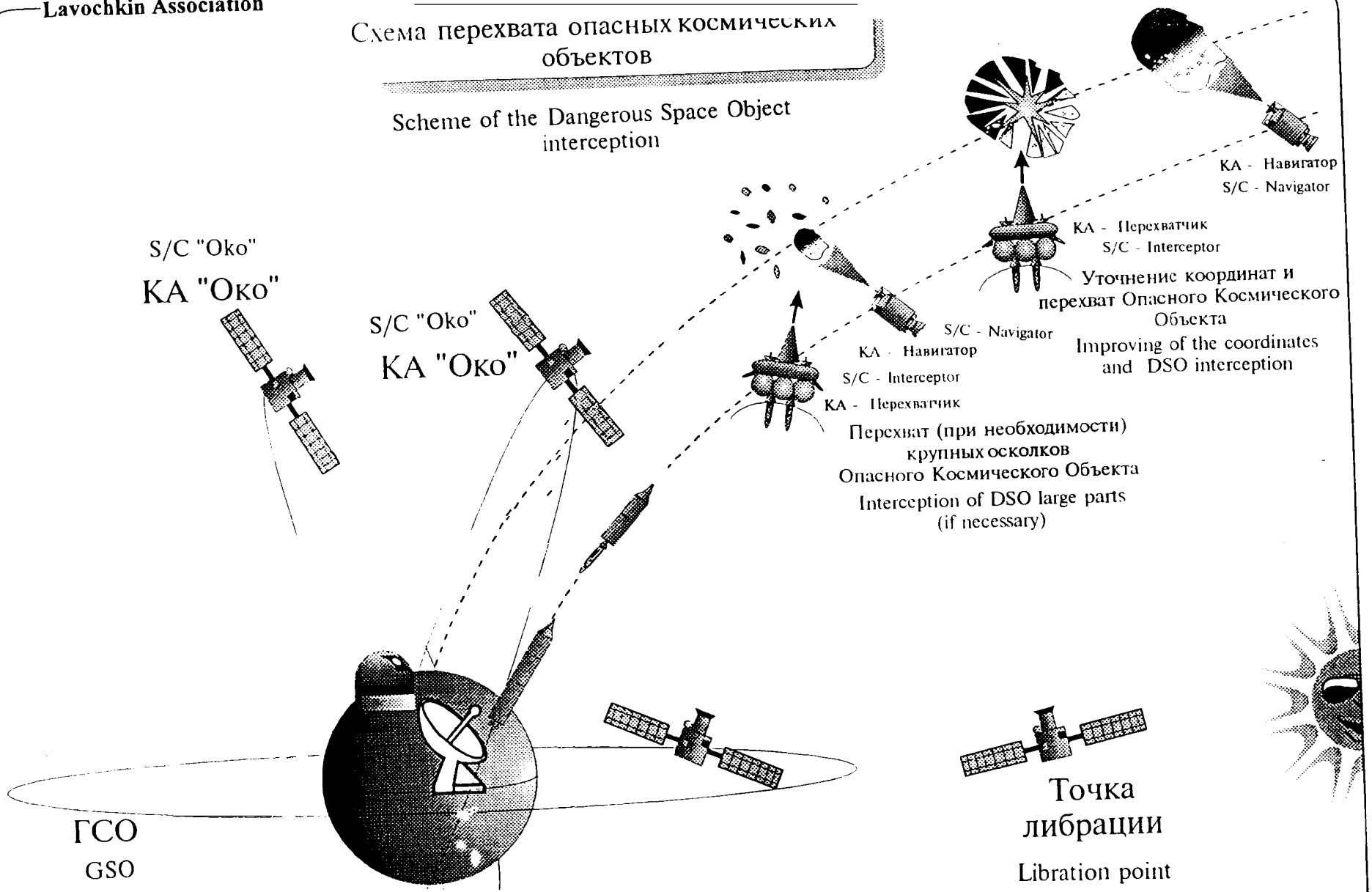

Fig. 2

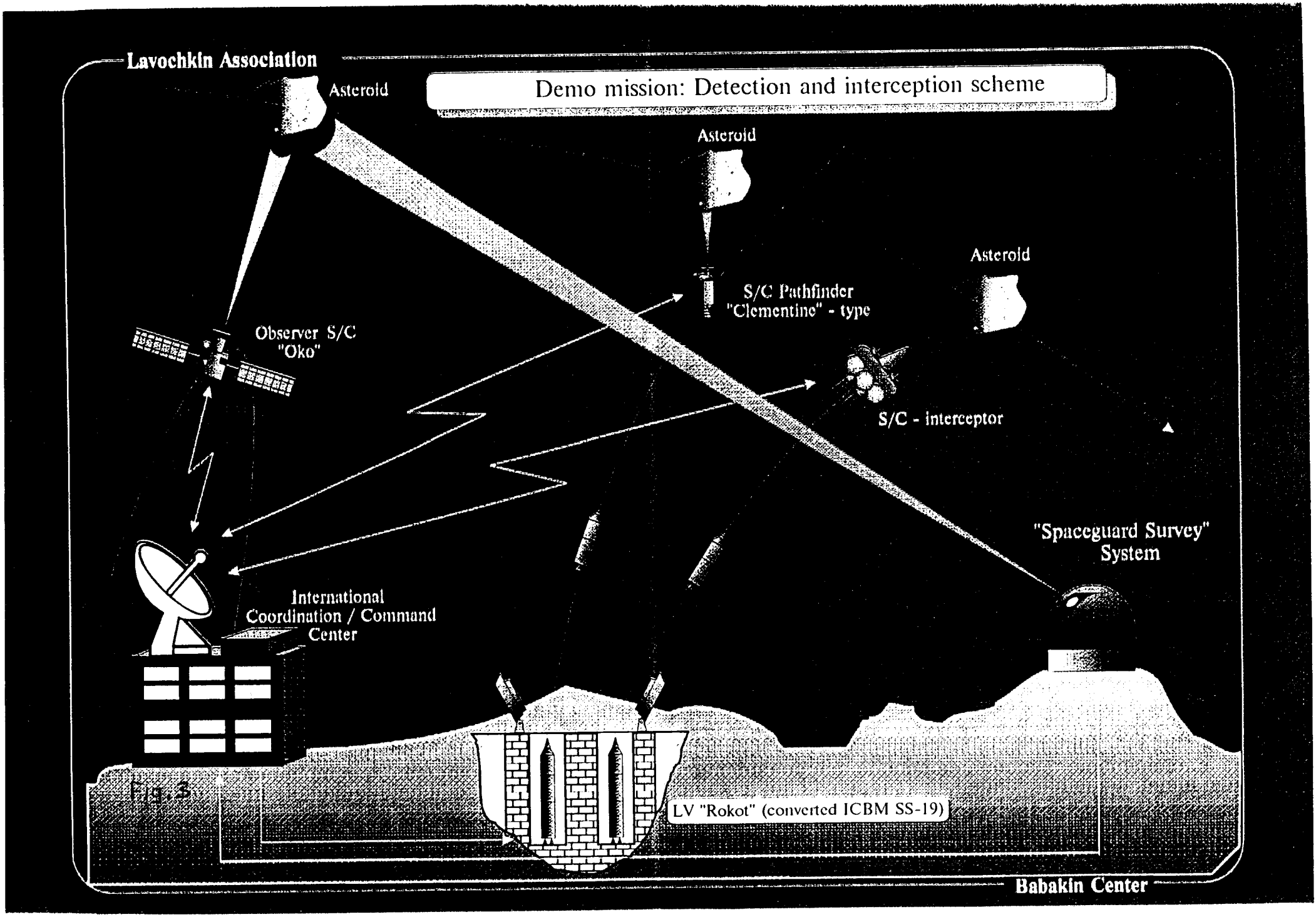
Lavochkin Association
Demo mission: Detection and interception scheme
Asteroid
Asteroid
Asteroid
S/C Pathfinder
"Clementine" - type
Observer S/C
"Oko"
S/C - interceptor
"Spaceguard Survey"
System
International
Coordination / Command
Center
LV "Rokot" (converted ICBM SS-19)
Babakin Center

Fig.3

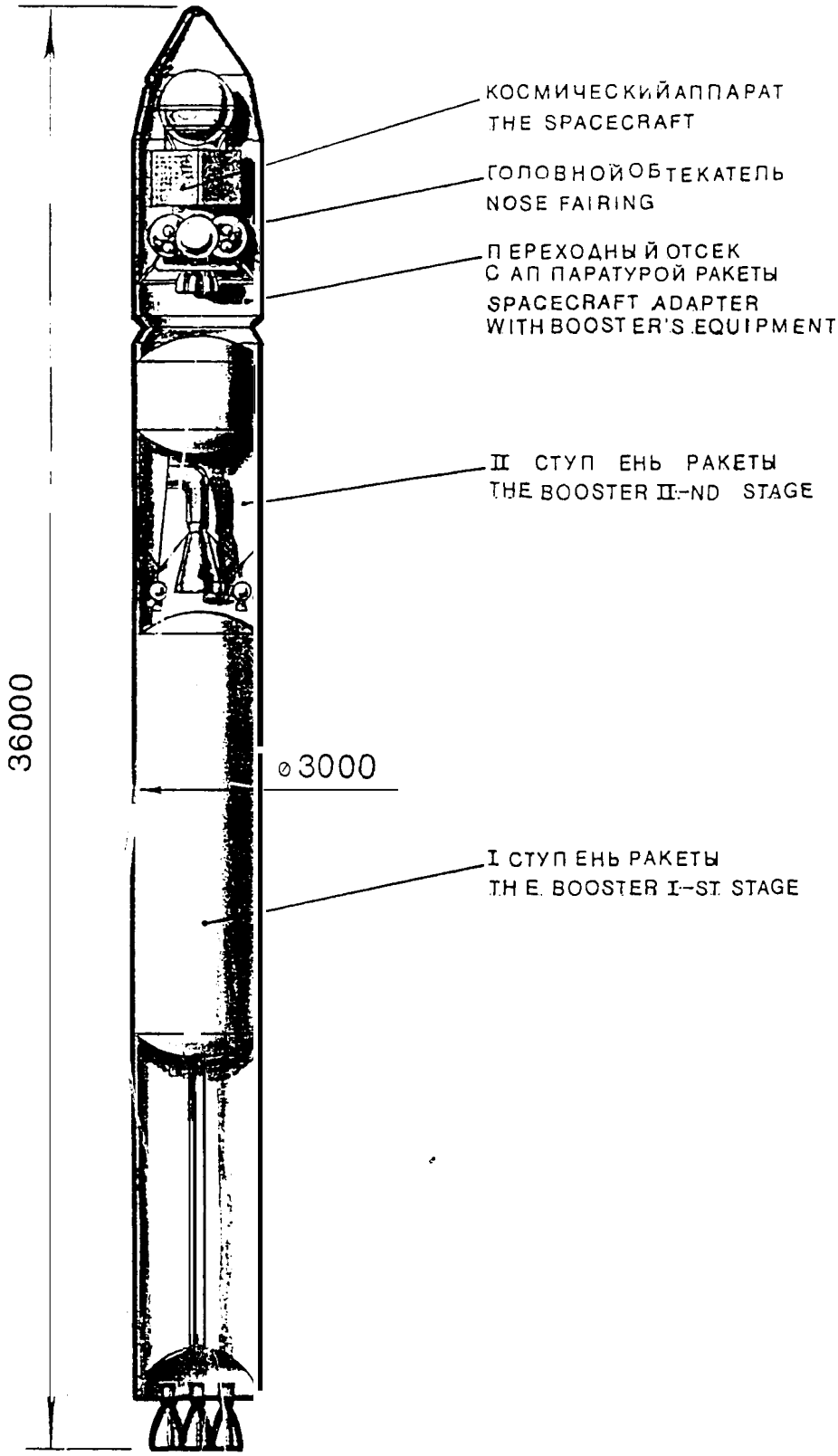

Fig. 4.

РАКЕТА-НОСИТЕЛЬ „СС-18„ С КОСМИЧЕСКИМ АППАРАТОМ

THE „SS-18„ SPACE BOOSTER WITH THE SPACECRAFT